THE INTERREGIONAL IMPACT OF INTERNATIONAL EXPORTS ON THE MIDWEST ECONOMIES

by

John J.Y. Seo and Geoffrey J. D. Hewings

REAL 04-T-9 October, 2004

The Interregional Impact of International Exports on the Midwest Economies

John JY Seo
Regional Economics Applications Laboratory, University of Illinois, 607 S. Mathews, Urbana, Illinois 61801-3671

Geoffrey J.D. Hewings
Regional Economics Applications Laboratory, University of Illinois, 607 S. Mathews, Urbana, Illinois 61801-3671
hewings@uiuc.edu

Abstract

While US export shares of total production remain small, little is known about the potential differential effect that international exports have on regional (state) economies. This paper presents the percentage of each state's output that is dependent both directly and indirectly on international commodity exports from the Midwest. Based on a Midwest Regional Input/Output Econometric Model, it explores the intra- and inter-regional economic linkage among six regions of five Midwest states and the rest of US region. The linkage is analyzed for 13 sectors but focuses exclusively on the impacts generated by exports from the merchandise sectors. The indirect export share is further decomposed into three sources: self-reinforcing, Midwest regional spillover, and non-Midwest spillover.

1. Introduction

The volume of foreign trade in and out of the United States has increased dramatically and the share of exports or imports in GDP for the nation has approximately doubled in the last two decades. However, the direct export share accounted for 4.9% of total national production in 1999. Studies show that, even though trade still remains a seemingly small fraction of U.S. GDP, merchandise trade as a share of merchandise value-added is quite high for the United States, and has been growing dramatically (Feenstra, 1998). The rising integration of world markets has brought with it a disintegration of the production process, in which manufacturing or service activities sourced outside the US are combined with those performed at home. The expansion of international business has also been a significantly increasing feature of production at a regional level. However, so far, only a limited number of studies have considered the role of international trade into a state or regional level (for one example, see Testa, *et al*., 2003).

In the next section, some background perspectives will be provided. Section 3 will present the methodology and the results will appear in section 4. The final section offers some concluding commentary.

2. Background Perspectives

Within the United States, regional economic trends should resemble those at the national level only to the extent that the structure of the regional economy resembles the structure of the national economy. In the realm of international business, state governments actively encourage exports (often through the establishment of trade offices in several international locations) and, in addition, they seek foreign direct investment to foster economic growth. In the last two decades, state export promotion expenditures have increased dramatically. Erickson (1989) and Coughlin *et al*. (1987) showed the effectiveness of such expenditure using cross-sectional, econometric models. There has clearly been evidence that a state's international export activity positively affects its own economy's growth. In accordance with international value-chain or disintegration (fragmentation) of production processes, international activities should affect regional economies but not necessarily in a uniform manner (see Jones and Kierzkowski, 2001, Hummels, *et al*., 2001 and Munroe *et al*., 2003). Clark *et al*. (1999) even showed that there are significant statistical differences in international exchange rates depending on US sub-regions. Economic cluster or agglomeration economies associated with the concentration of industry in a particular location have played a critical role in determining the specific impacts of international trade on regional and urban economics (Hewings *et al*. 1998, 2001, Maurel and Sedillot, 1999). However, regional economies are also linked together, often much more significantly that nations; hence, consideration needs to be given to the indirect effects of international trade, both in terms of interindustry repercussions and interregional transactions.

This paper is an attempt to link quantitatively the role of international activity to the regional structure of production and to measure the production portion of a region as an indirect feedback from other regions' international exports. In other words, as a result of the vertical and horizontal linkage between industries and regions, there are hidden non-export parts of outputs produced because of export production within and outside any given region. Using estimates of the ripple effects from such intra-and inter-regional linkage, this paper extracts the hidden

portions of export impacts on the regional economies. The focus of attention will be the Midwest region, and based on a multi-region general equilibrium model, the indirect effect is further decomposed into three sources of a state's own self-reinforcing (centripetal) force, inter-regional spillover from the other Midwest states, and inter-regional spillover from the non-Midwest region of the US. The industrialized Midwest is used for this exploration in examining the export trade inter-relationship between regions and activities, since has undergone a dramatic transformation in the last two decades of the twentieth century yet continues to support a significant durable manufacturing sector (Swonk, 1996, Testa, *et al*., 1997, Seo, *et al*., 2001). Unfortunately, data are not available to enable a comparison of the structure of markets served in 1999 in contrast to 1979, but there is not doubt that (as the data in table 1 suggest), the Midwest has become more dependent on international export markets while, at the same time, the individual constituent states have become more dependent on each other (Sonis *et al*., 2002). For comparative purposes, the non-Midwest is grouped into a region referred to as the Rest of the US.

<<insert table 1 here>>

Unlike the Rest of US region, the growth rate for goods-producing industries surpasses the overall economic growth in 1993 to 1999 in Midwest (see table 1). Although it is still below the 5.6% rest of US export share, merchandise exports grew in percentage terms more than twice the growth rate for total output growth in the same period, and grew faster in the Midwest than in the Rest of US region. The exports accounted for about 10% or more in the Midwest goods production in all states, with the following rank in 1999 – Michigan, Illinois, Ohio, Indiana, and Wisconsin. From 1993 to 1999, even though international exports grew the fastest in Indiana, and the slowest in Ohio, Michigan is the state with the highest export shares relative to its production, while Wisconsin (Indiana) is located at the bottom of the hierarchy in 1999 (1993). All the five states have experienced a mild but solid growth in their export-to-output ratios, around 25% in the time period, except for Wisconsin, whose ratio dropped only slightly.

3. Export Spillover: Methodology

To study the spillover effect, the Midwest Regional Input/Output Econometric Model[1] (MW-REIM) is utilized. The model was built in spring 2000 by REAL, based on 1992 and 1997 input-output data and annual regional data available up to 1996 from 1969, while focusing on

manufacturing sectors. MW-REIM is a multi-regional, dynamic general equilibrium model, which incorporates five Midwest states and a single rest of the US region. It links intra- and inter-regional trade relationships with data from the Commodity Flow Surveys of 1993 and 1997. Previous measures of agglomeration (e.g., Maurel and Sedellot, 1999; Ellison and Glaeser, 1997) are based on the Gini index[2], and do not encompass a comprehensive industrial and regional connection. However, because of its feedback framework, via its two major components of input/output module and time-series module, a REIM specification has an excellent advantage in measuring economic linkages quantitatively among the system variables. One can also extract forward and backward linkage by generating input-output tables and annual forecasts for the period 1998-2022 for the 13 sectors specified in the model.

The data on state-level merchandise exports to the world is obtained from Office of Trade and Economic Analysis, International Trade Administration, Dept. of Commerce. The data, Exporter Location series, is available for 1993 to 1999, by sectors; the specification roughly matches the SIC 2-digit code specification. The series allocates exports according to the physical location of exporters, i.e., it typically traces the export initiative to the point of sale. The series is ideally suited for export promotion purposes, where a key goal is to identify concentrations of international marketing activity. While a time-varying feedback system is one of the competitive advantages in the use of a REIM, the present analysis is limited only to a single year 1999. The variable mnemonics are also shown in table 2. In a typical single region REIM, each industrial sector is characterized by the set of its output (i.e., production sales measured in dollars), employment, and wage income. Each sector then is connected to other sectors, macro variables, and social demographic blocks via the chain system of REIM. The MW-REIM model is designed as an extension of single models, while focusing on inter-regional as well as intra-regional commodity flows within the United States.

<<insert table 2 here>>

Table 3 illustrates the region's orientation toward heavy manufacturing (sector 10, 8) especially in Michigan and Ohio, but the dependence becomes smaller in Illinois and Wisconsin. Non-durable manufacturing such as sector 11 is also one of the region's prominent industries, but non-merchandise sectors have grown fast in last decades, now accounting for between 46% (Indiana) to 63% (Illinois). One interesting observation from a comparison of the table with direct export shares, shown in table 6, is that, with the exception of the state of Michigan, major

production sectors overall do not coincide with major exporting sectors in the Midwest. For example, in Illinois, the two sectors of 11 and 8 are the largest goods-producing industries, but the sectors of 9 and 12 are the most active exporting group, experiencing an export-to-output ratio at more than 15% in 1999. On the other hand, in Michigan, the two major producers are sector 10 and 8, Transportation Equipment and Industrial Machinery and Equipment, which also yield the highest export ratios among the eleven industries. Michigan has maintained its reputation of a strong link to auto, and the capital equipment, industry so far, despite aggressive downsizing in the sector for the past two decades (Swonk, 1996).

<<insert table 3>>

For the inter- and intra-regional spillover analysis, an aggregated export promotion is assumed for each state and applied to our MW-REIM framework. In order to visualize economic flows among system variables, it is necessary to impose external shocks to the general equilibrium model and to analyze relationships for a new set of simulated solutions and set of initial solutions. Instead of applying different growth rates for all the sectors, it is more reasonable to assume a monotonic increase in total exports, resulting perhaps from a state export promotion program. Further, the ad hoc shock is enough to fit into our intention of measuring indirect export portion of output. Considering the 1993-99 growth, we applied 5, 10, and 20% monotonic export increases for all sectors in each state sales (i.e., percentage-wide simultaneous hikes for all 11-merchandise sectors). Because the results are similar, only the 10% shock case is shown in the paper, and the shock can be thought of state expenditure on its export sales promotion. The similarity arises from the fact that shocks to the system are linear at a point in time but non-linear over time (see Israilevich, *et al*., 1997 for more details)

REIM is a dynamic input/output model, where a value-added output (x_{ia}) for sector *i* and region *a* is expressed as, without time notation, *t*,

$$(1) \qquad x_{ia} = f(X, F, \beta); \qquad \tilde{\beta}_{ia} = g_{ia}\left(\frac{\mathrm{X}^{D}_{\mathrm{ia,\,t\text{-}1}}}{\mathrm{X}^{S}_{\mathrm{ia,\,t\text{-}1}}}, g\right)$$

where X is the output vector of all sectors, F is the final demand matrix, and $\tilde{\beta}$ is a diagonal matrix of $\tilde{\beta}_{ia}$'s, which are estimated parameters from the regression of historical output demand and supply and exogenous variables (g). The comprehensive feedback structure generates a

region-wide shock that produces a matrix of intra-and inter-regional multipliers, $\left.\frac{\Delta x_{ia}}{\Delta x_{ib}}\right|_{SS_b*}$, conditional on the simultaneous shock (ss_b^*) on all sectors in region *b*. As noted earlier, the stability of the multiplier effect is inherently built in REIM models, and thus the different shock amounts will not affect the results provided the shock is set within a reasonable range. The inter- and intra-regional integration relationship is, again, already embedded in our MW-REIM framework by its design of input/output and time-series modules, and an appropriate simulation will generate such outcomes.

4. Export Spillover: Results and Analysis

An overview of regional spillover effects is displayed in table 4. The table shows how much, as a percentage of output, the increase in a state's export generates additional activity within and outside of the state. The first row of table 4a indicates, for example, that the total positive effect on output due to Illinois's direct export is such that 64.5% remains within the state. That is, in the model, a 10%, or equivalently 2561m$, external shock on Illinois export, generates the total of 4494m$, as the sum of the direct and 1933m$ indirect impact (Table A1). The state's production increase also leaks into to other regions; the Rest of the U.S. region accounts for 22.9% of the total impact, while each Midwest state ranges from 2.6 to 3.7%, with the Rest of the Midwest (i.e. the four other states) accounting for almost 13% of the total impact. Similarly, table 4b describes the regional propagation effect of the indirect shock, which is total shock less direct shock amount of such as state's expenditure on promotion, and off-diagonal column average also shows approximate ranking of each region's spillover benefit from outside.

<<insert tables 4 and 5 here>>

Observations on the results suggest that, first, most of indirect impacts spill over within its own state and the rest of U.S. region. Secondly, the spillover effect seems to be quite different among the states. Ohio appears to possess the most effective economic structure, whose export promotion feeds back into own state by 51.9%, while it also receives the highest benefits of 7.8% on average from other regions. If greater degrees of leakage can be considered as less effective, then Wisconsin on the other hand is the least effective of the Midwest states with only 19.7%

self-reinforcing ratio, and an average 4.1% inter-regional inflow. Finally, there are some noticeable differences in bilateral inter-state propagation effect (table 5): For instance, Michigan's indirect export effect flows to Ohio are as high as 16.2%, while the reverse is only 7.6%. Thus, some states benefit more from the neighbors' export boost, while some benefit less. However, these ratios only focus on the total propagation flow. The actual direct and indirect portions of export relative to production be scaled by each region's production level and export share. Considering all these elements, our final interpretation of the direct and indirect export shares is summarized in Table 6.

Prior to discussing our summary results, some reference to the data provided in the Appendix need to be highlighted. Table A3 in Appendix reveals that the multiplier or ripple effect of Michigan is the highest among the six regions in output, and also in employment and income categories. The output multiplier of 3.7 implies that the shock generates additional outputs in the US, which are 3.7 times greater than the initial change in Michigan. Since this state has the second lowest self-reinforcing effect percentage-wise, after Wisconsin, most of these ripple effects propagate into the rest of the Midwest region (34.9%) and the rest of US (34.2%)[3]. On the other hand, even though Wisconsin has the lowest self-influence effect, most of their indirect ripple effects, 51.9%, go to the rest of US (table 3). Table A5 further illustrates that Wisconsin's inter-regional, and intra-regional, multipliers are overall quite small, and even the multiplier to the rest of US region is no higher than other states, suggesting that the state has the least inter-regional propagation effect of its international exports.

In practice, the following formula is used to derive the additional production, as a percentage of total state production, in sector *j* in region *a*, given export in region *b*:

$$(2) \qquad \text{export}_{ib}(\$) \cdot m_{ib}^{ja} \cdot {}^{1}\!\!\diagup\!\!_{x_{ja}} \; ; \qquad m_{ib}^{ja} = \left. \frac{\Delta x_{ja}}{Dx_{ib}} \right|_{SS_b *} .$$

m_{ib}^{ja} is the conditional trade multiplier, appearing in Appendix, Dx_{ib} is the direct impact (which is 10% of region *b*-sector *i*'s export), ss_{b}^{*} is the simultaneous shock on exports in region *b*, and Δx_{ja} is the sectoral impact difference due to the shock of ss_b^*. Summing up the equation for all regions of *b*=IL, …, RU, will yield the total indirect production *j* in region *a*. If dealing with the state-total only, then the formula reduces into inter-regional export-to-output (i.e., [total export

($) in region *b*]/[total output ($) in region *a*]) multiplied by inter-state trade multiplier (which is shown in row Total in the Appendix). If the source is from intra-regional trade, then notation *a* and *j* become *b* and *i* respectively, and the numerator of trade-multiplier should be the net production change of $\Delta x_{ib} - Dx_{ib}$. Also, for non-merchandise sector *j*=3 and 13 having no direct export portions, the formulas are modified as $\text{export}_b(\$) \cdot \Delta x_{ja} / Dx_b \cdot 1 / x_{ja}$.

Finally, we are in the stage of introducing portions of outputs that indirectly depend on exports. Three sources are identified for indirect export effect on production: (1) self-reinforcing feedback effect, (2) inflow from other Midwest state, and (3) inflow from the rest US. In other words, the sources generate additional non-export output production due to intra-state (or -regional) trade, the output due to exports of the other four Midwest states, and the output due to exports in the Rest of US region. Along with the direct export shares, the results are displayed in table 6: Table 6a compares, at the sectoral level, direct and the indirect export portions as percentage of total output, and the three decomposed sources of indirect export are displayed in table 6b. The major concern should be on the whole economic production, as a sum of all sectoral activities; if the focus is on the interactions among goods-producing industries, and since the analysis is limited to merchandise exports, the 'Total' portion is adjusted by excluding non-commodity sectors of 3 and 13 in each region and examined in 'Merc' row.

<<Insert table 6 here>>

Table 6a shows that the indirect production portion accounts for from 1.5% (Wisconsin) to 4.7% (Michigan) of the total production in each region. These figures represent the ripple effects of each state within the 1999 US economy, generated from the US international exports. To figure out which state benefits most form the ripple effect, we may simply derive an indirect-to-direct ratio by dividing ID column by D column. This regional hierarchy is ordered as follows: OH (.76), IN (.69), MI (.63), IL (.63), and WI (.45), with Rest of US (.74). The order literally represents a production efficiency level relative to US exports, and implies a fundamental intra- and inter-regional inflow linkage of each regional economy. In other words, as the US export level changes, each region's production changes by the ratio in proportion to its export level. If one adjusts for merchandise industry, the order changes slightly: IN (.44), OH (.37), MI (.35), WI (.35), and IL (.29) with Rest of US (.32). When considering goods-production flow alone,

the feedback inflow of merchandise exports becomes largest in Indiana and smallest in the non-Midwest region, and in Illinois in Midwest. The changes in the ratios are because of larger portion of service sector (Illinois, Rest of US), or larger economy size (Ohio versus Indiana).

A further decomposition of indirect export share is shown in table 6b, depending on the regional origin of the external influence, as intra-regional, and intra-activity, (1) feedback (denoted as '*in*'), (2) inter-regional spillover from the other Midwest states (denoted as '*MW*'), and (3) inter-regional spillover from the rest of the US (denoted as '*RU*'). These three shares of course sum to the indirect share in table 6a. The decomposition allows us to compare how each state and each sector are related to one another in international export. The table overall shows that the '*in*' part is the dominant source of the total indirect export share (*ID*) compared to the other two components, and also, the '*MW*' portion is 5 to 10 times larger than the '*RU*' number in a state.

In detail, first of all, the intra-regional feedback accounts for a large part of indirect share for some states/regions: the '*in*' figure is 4.4% of total production in Michigan, around 2.5% in Ohio, Illinois, and Indiana, and only 0.9% in Wisconsin, and a high of 3.6% in the rest of US. For Michigan, even though the self-reinforcing effect is not very high (table 4b), the state's economy is heavily dependent on international export, exporting 7.5% of its total production, and a 1.84 intra-state multiplier should be large enough to generate such a high self-fulfilling portion. For the rest US, the corresponding '*in*' figure of 3.6% occupies most (97%) of the '*ID*' number, the total indirect spillover, meaning that an inflow from Midwest's exporting power is considerably low at 0.11% of the gross production in the region.

Secondly, the '*MW*' parts, production shares due to other Midwest states' exports, are somewhat stable at with the order of Indiana (.75%), Wisconsin (.57%), Ohio (.50%), Illinois (.24%), and Michigan (.21%), and again Rest US (.11%). The hierarchy is still the same for the case of commodity sector total, '*Merc*.' A series of *MW*-to-*in* ratio, similar to indirect-to-direct ratio as used earlier, exhibits a wider range and provides a clear view of each state's economic dependence to the Midwest. The series is ordered at 0.63 in Wisconsin, 0.36 in Indiana, 0.19 in Ohio, 0.10 in Illinois, and 0.05 in Michigan, and 0.03 in the rest of US. They stay in the same order even in case of merchandise sector total ('*Merc*'), but the figures rose to the range of 1.16 to .07%. Meanwhile, the export influence from '*RU*' spreads out fairly evenly to the Midwest states, even though their influence is no greater than 0.8% of production for all five Midwest

states. Among them, the inflow is largest in Illinois, having a *RU*-to-*in* ratio of .04, and smallest in Michigan with .01.

5. Conclusions

The increased influence of international trade in the US will continue to penetrate local economies, and the slicing of value-chain linkage between industries and regions in a country generates trade ripple effects via intra- and inter-regional flows. To exploit such a connection, this paper derives regional non-export parts of output production, thanks to inflows from own and other states' international exports. Simulation results show that the seemingly small portions of direct export data hide additional propagation effects generated via industrial and regional feedback connection. In 1999, for the Midwest economy, indirect production for all sectors accounts for about 3.1%, while the direct merchandise export share is 4.87%, of total Midwest production. For the nation, the indirect export-driven production accounts for 3.6% and the direct share is 4.93% in the same year.

Table 6 is the final summary of this study, showing rich details of intra- and inter-regional export relationship between the selected sectors and regions. Overall, the feedback from the rest economy to Midwest occupies less than 1% of production, which is a lot smaller than the reverse and indicates the hollowing-out of Midwest economy (Hewings, *et al*. 1998). Meanwhile, region-wide self-reinforcing effects play a major role in the production chain system for most states, but some of the smaller states, such as Wisconsin and Indiana, enjoy considerable inflows from the adjacent large Midwest states. Interestingly, each state's Midwest connection or dependence measure, *MW*-to-*in* ratio, is ranked as a reverse hierarchy of active level of merchandise exports, in terms of both direct export share and export level measured in dollars. It implies that, a small open economy unit in a geographic scope of agglomeration, like these two states in the Midwest Manufacturing Belt, depends more on inter-regional economic structure and benefits more as inflows increase from a changing national economy.

The table can be further analyzed at sectoral level. The scale economy of differentiated products has mainly caused an increasing trend of international merchandise trade (Feenstra, 1998), but the interpretation appears to be somewhat different for each sector(s). Among the major industries in Midwest, for example, which are ordered at sector 10, 11, 8, 9, etc., the *MW*-to-*in*

ratios are noticeably larger at around 1 in most states in non-durable manufacturing, such as sector 11 and 4. The ratios become the smallest at around .05% for light durables of sector 9 (Electronics), and, for heavy machinery (sector 10 and 8) at around .15%. The heavy durable manufacturing, exemplified as the Detroit auto industry, appears to take scale economy advantages from its industrial cluster, both at a state-level (the ratio for sector 10 becomes the smallest in Michigan.) and at a larger Midwest scope (the ratios of *RU*-to-*in* are almost the smallest among all sectors). The non-durable manufacturing, as a Midwest industrial cluster, may take an advantage of the interactions of scale economies at the inter-regional level, while the light durable manufacturing, which requires a small sunk cost, utilizes initial location advantage (such as manufacturing labor pool and infrastructure). These interpretations appear consistent with those identified in Parr *et al*. (2002). Increasing fragmentation of production, exploiting scale economies and responding to consumer preferences for increased variety is changing the geography of production. Increasingly, it will become difficult to separate out "regional" versus "international" effects as the process of vertical integration (Hummels *et al*., 2001) operates at a variety of spatial scales. One might speculate that as a result of this greater integration, state-level economies would respond to business cycles in a similar fashion; however, Park and Hewings (2003) demonstrate that this is not the case for these same Midwest states, although Kouparitsas (2002) finds striking similarities at the BEA region level.

Finally, it should be noted that our calculation of such relationships was entirely possible based on the tables in Appendix, that are the matrices of intra- and inter-regional multipliers derived from our basic model. Even though the analysis is limited to a single year 1999, a dynamic general equilibrium model, like MW-REIM, captures general trends of technological changes over time and potential structural changes, and thus produces similar analyses for advanced years. In this paper, the analysis has been limited to merchandise exports and export's indirect production share, but for a comprehensive economic review, advanced research may include international imports and foreign direct investment at regional level.

References

Ciccone, A. and R. Hall, 1996, "Productivity and the Density of Economic Activity," *American Economic Review*, 86, 54-70.

Clark, Don P., W.C. Sawyer, and Richard Sprinkle, 1999, "Regional Exchange Rate Indexes for the United States," *Journal of Regional Science*, 39, 149-166.

Coughlin, Celtus, and Phillip A. Cartwright, 1987, "An Examination of State Export Promotion and manufacturing Exports," *Journal of Regional Science*, 27, 3, 439-449.

DeMelo, Jaime, and Sherman Robinson, 1989, "Product Differentiation and the Treatment of Foreign Trade in Computable General Equilibrium Models of Small Economics," *Journal of International Economics*, 27, 47-67.

Ellison, G. and E., Glaeser, 1997, "Geographic Concentration in U.S. Manufacturing Industries: a dartboard approach," *Journal of Political Economy*, 105, 889-927.

Erickson, Rodney A., 1989, "Export Performance and State Industrial Growth," *Economic Geography*, 65, 280-292.

Feenstra, Robert C., 1998, "Integration of Trade and Disintegration of Production in the Global Economy," *Journal of Economic Perspectives*, 12, 31-50.

Fujita, M. and J.-F. Thisse, 1996, "Economics of Agglomeration," *Journal of Japanese and International Economics*, 10, 339-78.

Hewings, Geoffrey J. D., Michael Sonis, J. Guo, P. Israilevich, and G. Schindler, 1998, "The Hollowing-Out Process in the Chicago Economy, 1975-2011," *Geographical Analysis*, 30, 217-234.

Hewings, Geoffrey J.D., Yasuhide Okuyama, and Michael Sonis, 2001. "Economic Interdependence within the Chicago Metropolitan Region: A Miyazawa Analysis," *Journal of Regional Science*, 41, 195-217.

Hummels, David, Jun Ishii and Kei-Mu Yi, 2001. "The nature and growth of vertical specialization in world trade," *Journal of International Economics*, 54, 75-96.

Israilevich, Phillip R., Geoffrey J.D. Hewings, Michael Sonis, and Graham Schindler, 1997, "Forecasting Structural Change with a Regional Econometric Input-Output Model," *Journal of Regional Science*, 37, 565-590.

Jones, R.W., and Kierzkowski, H. 2001. A framework for fragmentation, in Sven W. Arndt and H. Kierzkovski (eds), *Fragmentation: new production patterns in the world economy*. Oxford University Press, New York.

Kouparitsas, Michael A. 2002. "Understanding US regional cyclical comovement: How important are spillovers and common shocks?" *Economic Perspectives* (Federal Reserve Bank of Chicago) 4th Quarter, 30-41.

Krugman, Paul, 1998, "Space: The Final Frontier," *Journal of Economic Perspectives*, 12, 161-174.

Lopez, Elena, and Rigoberto A. Lopez, 1996, "Market Structure and the Impacts of Imports on Price Cost Margins," *Review of Industrial Organization*, 11,107-113.

Maurel, Francoise, and Beatrice Sedillot, 1999, "A Measure of Geographic Concentration in French Manufacturing Industries," *Regional Science and Urban Economics*, 29, 575-604.

Munroe, D.K., Hewings, G.J.D. and Guo, D. (2003) "The Role of Intraindustry Trade in Interregional Trade in the Midwest of the US," *Discussion Paper* 99-T-7 (revised, 2003)

Regional Economics Applications Laboratory, University of Illinois, Urbana (www.uiuc.edu/unit/real)

Park, Yang Su and Geoffrey J.D. Hewings 2003. "Does Industry Mix Matter in Regional Business Cycles?" *Discussion Paper* 03-T-29, Regional Economics Applications Laboratory, University of Illinois, Urbana (www.uiuc.edu/unit/real)

Parr, John B., Geoffrey J.D. Hewings, Jungyul Sohn, and Suahasil Nazara, 2002. "Agglomeration and Trade: Some Additional Perspectives," Regional Studies, 36, 675-684.

Sanyal, Kalya and Ronald W. Jones, 1982, "The Theory of Trade in Middle Products," *American Economic Review*, 72, 16-32.

Seo, John J.Y., Hewings, Geoffrey J.D. and Sonis, Michael. (2004) "Vertical Connections in the Midwest Economies: the Role of Internal and External Trade," *Discussion Paper* 04-T-10, University of Illinois, Urbana (www.uiuc.edu/unit/real)

Sonis, Michael, Geoffrey J. D. Hewings, and Yasuhide Okuyama, 2002. "Vertical Specialization and Spatial Production Cycles in Interregional Trade: Feedback Loops Analysis of the Midwest Economy. In G.J.D. Hewings, M. Sonis and D. Boyce (eds) *Trade, Networks and Hierarchies* (Heidelberg, Springer-Verlag).

Swonk, Diane C., 1996, The Great Lakes Economy Revisited, a series paper for 1996 workshop FRB, Chicago, The Midwest Economy: Structure and Performance.

Testa, W., Thomas H. Klier and Richard H. Mattoon. (ed) (1997) *Assessing The Midwest Economy: Looking Back for the Future*, Chicago, Federal Reserve Bank.

Testa, W., Thomas H. Klier and Alexei Zelenev. (2003) "Estimating US metropolitan export and import competition," *Economic Perspectives* (Federal Reserve Bank of Chicago) 4th Quarter, 13-27.

Table 1. Growth Change, 1993-99, Midwest and Rest of US

Change (%)	Illinois	Indiana	Michigan	Ohio	Wisconsin	Rest US
Commodity Export	51.6	72.7	63.8	50.5	64.3	49.6
Commodity Output	29.3	32.7	34.1	27.4	28.0	13.3
Total Output	20.6	26.6	27.8	23.3	23.2	16.9
GRP	17.1	19.9	20.7	18.4	16.5	15.5
Stats, 1999						
Direct Export Share:	11.5	7.9	15.0	10.4	6.5	14.1
Goods (All Sectors)	(4.3)	(4.2)	(7.5)	(4.2)	(3.3)	(5.0)
Commodity Export *	30.9	14.4	41.5	26.6	9.5	562.8
Total Output	716.5	341.4	548.7	627.8	289.7	11046.7

Source: BEA, REAL (MW-REIM).
Note. Construction and Service Industries are not included in 'Exports' category.
*: Monetary units are in 1999billion$.

Table 2: Sectors Identified in the Midwest Model

Number	Sector Title	SIC
1	Agriculture, Forestry and Fisheries	01,02,07,08,09
2	Mining	10, 12, 13, 14
3	Construction	15, 16, 17
4	Food and Kindred Products	20
5	Chemicals and Allied Products	28
6	Primary Metals Industries	33
7	Fabricated Metal Products	34
8	Industrial Machinery and Equipment	35
9	Electronic and other Electric Equipment	36
10	Transportation Equipment	37
11	Other Non-durable Manufacturing Products	21-23,26,27,29-31
12	Other Durable Manufacturing	24,25,32,38,39
13	TCU, Service, and Government Enterprises	40-42,44-65,67,70,72,73, 75,76

Table 3. Actual Output Levels (%, Total Output), 1999.

Sector	Illinois	Indiana	Michigan	Ohio	Wisconsin	Rest US
1	1.6	1.7	0.7	1.1	1.2	2.6
2	0.4	0.4	0.3	0.5	0.1	1.2
3	5.3	5.5	4.8	5.2	5.8	6.0
4	5.0*	3.6	2.5	3.8	8.1*	3.6*
5	3.2	4.1	2.4	3.3	1.9	3.1
6	1.8	6.8*	1.9	3.9	1.8	1.2
7	2.8	3.9	4.3	4.3	3.4	1.3
8	5.8*	5.4	5.6*	5.7*	8.9*	2.5
9	4.1	4.4	1.2	3.9	5.3	2.7
10	3.0	12.1*	22.6*	12.2*	4.9	2.5
11	7.2*	7.1*	5.4*	6.1*	9.8*	7.7*
12	2.5	4.4	3.8	3.6	4.9	3.6*
13	57.4	40.6	44.6	46.5	43.7	62.0
Total	$602.129 b	$286.924b	$461.143b	$527.543b	$243.524b	$9285.487b

Note. The projected output levels are obtained from the MW-REIM, and monetary units are in 1992 million dollars. * indicates the top three major industries, other than sector 13, in each state.

Table 4. Regional Spillover (%) due to Export Expansion, By 10%, 1999, Output.

Table 4a Spillover (%) of *Total* Impact

Source/spread	IL	IN	MI	OH	WI	Rest of Midwest	Rest US
IL	64.5	3.2	3.2	2.6	3.7	12.7	22.9
IN	3.5	64.4	5.4	4.8	4.8	18.5	20
MI	4.4	5.7	49.5	11.8	3.6	25.5	25
OH	2.4	2.9	4.8	69.8	1.7	11.8	18.5
WI	7.1	2.8	4.6	3.4	49.46	17.9	32.6
Rest US	3.3	1.8	3.5	3	2.1		86.3

Table 4b Spillover (%) of *Indirect* Impact

	IL	IN	MI	OH	WI	Rest of Midwest	Rest US
IL	43.8	5.1	5	4.1	5.8	20.0	36.2
IN	5.7	42.7	8.7	7.7	3.2	25.3	32.1
MI	6.1	7.8	30.9	16.2	4.9	35.0	34.2
OH	3.9	4.6	7.6	51.9	2.6	18.7	29.5
WI	11.3	4.4	7.4	5.4	19.7	28.5	51.9
Rest US	6.4	3.5	6.7	5.8	4.1		73.5
Inter-Avg	6.7	5.1	7.1	7.8	4.1		36.8

Note. The shaded areas denote the state associated with positive export impacts, and the shock spreads into row. 'Inter-Avg' indicates the column average of off-diagonal (or inter-regional) elements.

Table 5 Balance of Trade in Spillovers

	IL	IN	MI	OH	WI	Positive
IL		+	+	-	+	3
IN	-		-	-	+	1
MI	-	+		-	-	1
OH	+	+	+		+	4
WI	-	-	+	-		1

Note: Entries indicate whether the spillover from state *r* to state *s* as a percentage of state *r*'s total export impact is greater than or less than state *s*'s spillover to sector *r*.

Table 6. Direct and Indirect Export Shares in Production (%), By 13 Sectors, 1999.
Table 6a. Direct and Indirect Export Shares in Production (%).

	IL		IN		MI		OH		WI		RUS	
	D	*ID*	*D*	*ID*	*D*	*ID*	*D*	*ID*	*D*	*ID*	*D*	*ID*
1	12	6.4	1	3.9	5	6.7	1	3.9	3	4.1	15.4	7.6
2	4	11.4	1	9.5	12	15.0	24*	16.2	21*	13.1	6.8	6.4
3	-	2.0	-	1.7	-	3.3	-	1.5	-	0.9		2.5
4	4	1.8	1	2.0	3	1.5	3	2.0	2	2.1	1.5	1.6
5	19*	5.8	15	4.3	15*	6.7	14	5.7	9	2.5	8.0	4.8
6	6	7.9	3	11.2	7	8.1	5	10.0	2	6.8	2.6	4.6
7	5	4.4	6	4.8	13	8.2	7	5.0	4	2.9	8.8	6.8
8	21*	2.8	10	1.1	16*	6.2	14	3.9	13	1.5	33.3	6.8
9	20*	2.6	22*	2.9	35*	5.3	8	3.0	5	1.7	30.2	6.9
10	10	2.1	8	2.6	19*	5.7	9	2.1	6	1.0	19.6	7.5
11	3	2.1	2	2.4	3	2.4	3	3.0	3	2.7	3.0	2.4
12	19*	2.4	10	2.8	14	3.4	14*	4.0	13	1.7	29.3	6.4
13	-	2.4	-	2.3	-	4.2	-	2.8	-	0.7		3.2
Total	4.3	2.7	4.2	2.9	7.5	4.7	4.2	3.2	3.3	1.5	5.0	3.7
		63[#]		46		49		52		49		68
Merc	11.5	3.3[#]	7.9	3.5	15.0	5.3	10.4	3.8	6.5	2.3	15.2	4.9

Note. 'Total' in Direct (ID) indicates the direct (indirect) commodity exports (%) relative to total output, which includes all industrial activities. 'Merc' in Direct (ID) indicates the direct (indirect) commodity exports (%) relative to total merchandise production, which includes all industrial activities less productions in Sector 3 and 13. # : The Construction (3) and Service (13) sectors account for 63% in Illinois, for example, of total output. If weighting toward adjustment of merchandise sectors only, the percentage will approximately increase from 2.7 to 3.3%. * indicates industry with more than 15% export share in its production.

Table 6b. Indirect Export Share in Production (%), Midwest Exports, By 13 Sectors, 1999

	IL			IN			MI			OH			WI			RUS	
	in	*MW*	*RU*	*in*	*MW*	*RU*	*in*	*MW*	*RU*	*in*	*MW*	*RU*	*in*	*MW*	*RU*	*in*	MW
1	4.0	2.40	.03	.5	3.38	.02	1.5	5.17	.01	.8	3.03	.02	.9	3.21	.01	6.5	1.08
2	1.6	9.66	.11	.4	9.08	.05	4.1	1.81	.06	4.7	11.4	.12	.7	12.4	.02	3.9	2.48
3	2.0	.00	.00	1.7	.00	.00	3.3	.00	.00	1.5	.01	.00	.9	.00	.00	2.5	.01
4	1.2	.40	.18	.9	1.03	.08	1.3	.15	.06	1.1	.81	.09	.5	1.33	.29	1.3	.25
5	5.5	.27	.06	3.7	.52	.06	6.5	.11	.04	5.2	.41	.05	1.6	.82	.03	4.7	.06
6	4.4	2.05	1.40	2.2	5.67	3.29	5.7	1.03	1.32	3.7	3.68	2.64	1.5	4.36	.89	3.5	1.10
7	3.3	.60	.51	3.3	1.20	.31	6.8	.71	.67	2.9	1.29	.82	1.2	1.36	.32	6.5	.32
8	2.3	.33	.13	.9	.19	.04	6.0	.12	.06	3.5	.37	.07	1.0	.43	.10	6.7	.11
9	2.5	.08	.01	2.7	.21	.01	5.2	.06	.00	2.7	.28	.02	1.3	.33	.04	6.8	.06
10	1.8	.24	.05	2.2	.32	.10	5.0	.25	.43	1.5	.33	.23	.5	.47	.05	7.4	.08
11	1.5	.58	.06	1.2	1.15	.03	2.0	.31	.05	1.8	1.19	.05	1.0	1.59	.06	2.2	.16
12	2.2	.16	.01	2.4	.42	.01	3.2	.14	.01	3.7	.31	.01	1.2	.44	.02	6.3	.07
13	2.4	.01	.00	2.3	.02	.00	4.2	.01	.00	2.8	.02	.00	.7	.01	.00	3.2	.01
Total	2.4	.24	.05	2.1	.75	.06	4.4	.21	.05	2.6	.50	.06	.9	.57	.04	3.6	.11
	63[#]			46			49			52			49			68	
Merc	2.49[#]	.63[#]	.12[#]	2.04	1.37	.10	4.64	.41	.09	2.60	1.02	.13	.96	1.11	.07	4.62	.34

Note. There are three sources of indirect export effect on production. 'in' stands for the additional output produced in % via intra-state (or region) industrial interactions, 'MW' stands for the output (%) due to exports of other 4 Midwest states, and 'RU' stands for the output due to exports in the Rest of US region. 'Merc' indicates, as in Table 4A, the total indirect effect, while considering total as total merchandise production, which includes all industrial activities less productions in Sector 3 and 13. #: The Construction (3) and Service (13) sectors account for 63% in Illinois, for example, of total output. If weighting toward adjustment of merchandise sectors only, the percentage will approximately increase from 2.4 to 2.49%.

Appendix: Production Changes due to Export Expansion, By 10%, 1999.

Table A1. Illinois

Output

	US		IL	IN	MI	OH	WI	RU
	m$	% [1]	% [2]					
1	256	2.2	1.48	0.03	0.01	0.01	0.11	0.55
2	44	4.4	1.61	0.22	0.21	0.14	0.11	2.09
3	138		0.02	0.00	0.00	0.00	0.00	0.02
4	230	1.9	1.44	0.02	0.01	0.01	0.18	0.22
5	576	1.6	1.41	0.03	0.01	0.01	0.04	0.08
6	454	7.6	4.63	1.18	0.12	0.24	0.23	1.15
7	372	4.6	3.15	0.16	0.25	0.29	0.24	0.56
8	997	1.4	1.12	0.03	0.02	0.02	0.05	0.11
9	601	1.2	1.15	0.01	0.00	0.01	0.03	0.05
10	456	2.5	1.21	0.13	0.50	0.26	0.08	0.29
11	394	3.5	2.33	0.12	0.09	0.09	0.25	0.67
12	417	1.4	1.13	0.03	0.03	0.02	0.05	0.16
13	2044		0.32	0.02	0.02	0.02	0.02	0.39
Total	6978m$	2.72	1.75	0.09	0.09	0.07	0.10	0.62
			4494m$	224	221	183	256	1599
Direct	2561							
Indirect	4417							
Multiplier	2.72							

Net Exports	1021	53	67	51	51	438

Income

Total	Direct	Indirect	Multiplier
1879	543	136	3.46

Employment

Total	Direct	Indirect	Multiplier
60	14	47	4.39

Note. % [1] stands for the percentage change in national output relative to the initial shock amount in Illinois. For example, the sector 1 increases 256 m$ nationally in accordance with 10% (or equivalently 116m$) export increase in all merchandise sectors in Illinois. This is the same for inter-regional, inter-sectoral multiplier: Row-sum of % [2] equals to % [1]. For sector 3 and 13, refer to the main text. 'Net Export' stands for the state-wise net export outside to the state. Thereby, it includes inter-state flows as well as international exports.

Table A2. Indiana

Output

	US		IL	IN	MI	OH	WI	RU
	m$	% [1]	% [2]					
1	32	10.8	0.92	4.21	0.50	0.57	0.13	4.49
2	13	12.6	1.51	1.90	0.56	0.77	0.08	7.81
3	60		0.00	0.02	0.00	0.00	0.00	0.02
4	56	3.7	0.13	2.51	0.06	0.09	0.24	0.71
5	258	1.5	0.03	1.34	0.02	0.02	0.01	0.07
6	247	3.9	0.06	3.01	0.10	0.19	0.07	0.50
7	212	3.1	0.12	2.13	0.26	0.24	0.08	0.26
8	236	1.5	0.06	1.10	0.07	0.07	0.04	0.14
9	331	1.2	0.01	1.14	0.00	0.01	0.02	0.03
10	568	2.0	0.05	1.38	0.28	0.17	0.03	0.11
11	176	4.2	0.27	2.53	0.20	0.24	0.22	0.74
12	215	1.6	0.02	1.30	0.05	0.04	0.04	0.16
13	803		0.04	0.22	0.03	0.03	0.01	0.34
Total	3210	2.6	0.09	1.70	0.14	0.13	0.05	0.53
			113	2066	173	153	63	642
Direct	1214							
Indirect	1996							
Multiplier	2.64							

Net Exports	29	475	52	41	12	438

Income

Total	Direct	Indirect	Multiplier
825	251	573	3.28

Employment

Total	Direct	Indirect	Multiplier
26	6	20	4.36

Table A3. Michigan

Output

	US		IL	IN	MI	OH	WI	RU
	m$	% [1]			% [2]			
1	81	5.1	0.18	0.22	1.42	0.28	0.08	2.92
2	80	5.7	0.11	0.11	1.57	0.45	0.02	3.49
3	309		0.00	0.00	0.02	0.01	0.00	0.05
4	151	5.0	0.25	0.26	1.99	0.42	0.45	1.65
5	427	2.5	0.09	0.12	1.72	0.18	0.07	0.32
6	696	10.9	0.43	1.76	4.75	1.83	0.34	1.76
7	881	3.6	0.15	0.21	2.19	0.50	0.10	0.41
8	1204	2.8	0.24	0.04	1.58	0.27	0.19	0.50
9	328	1.8	0.04	0.06	1.18	0.15	0.07	0.25
10	4217	2.1	0.06	0.16	1.35	0.29	0.08	0.18
11	586	9.0	0.54	0.51	4.11	0.95	0.76	2.15
12	514	0.1	0.05	0.11	1.30	0.14	0.09	0.41
13	3358		0.05	0.04	0.25	0.11	0.02	0.50
Total	12832	3.7	0.16	0.21	1.84	0.44	0.13	0.93
			570	730	6352	1516	460	3205
Direct	3460							
Indirect	9372							
Multiplier	3.71							

Net Exports			137	166	1831	400	12	864

Income

Total	Direct	Indirect	Multiplier
3530	844	2686	4.18

Employment

Total	Direct	Indirect	Multiplier
103	15	88	6.68

Table A4. Ohio

Output

	US		IL	IN	MI	OH	WI	RU
	m$	% [1]			% [2]			
1	52	7.4	0.21	0.35	0.45	2.81	0.11	3.42
2	103	1.7	0.01	0.01	0.04	1.25	0.00	0.38
3	95		0.00	0.00	0.00	0.02	0.00	0.02
4	122	2.4	0.05	0.04	0.03	1.78	0.15	0.35
5	428	1.8	0.03	0.04	0.02	1.58	0.01	0.08
6	506	4.8	0.06	0.31	0.09	3.79	0.05	0.47
7	339	2.1	0.05	0.05	0.13	1.69	0.03	0.15
8	724	1.7	0.08	0.03	0.07	1.33	0.04	0.17
9	271	1.7	0.01	0.01	0.01	1.53	0.04	0.10
10	926	1.6	0.02	0.05	0.23	1.21	0.02	0.09
11	335	3.3	0.10	0.11	0.11	2.33	0.13	0.50
12	480	0.2	0.01	0.03	0.04	1.29	0.02	0.12
13	1506		0.02	0.02	0.02	0.31	0.01	0.30
Total	5886	2.7	0.07	0.08	0.13	1.87	0.04	0.50
			143	170	279	4109	97	1088
Direct	2194							
Indirect	3692							
Multiplier	2.68							

Net Exports			36	42	82	1116	18	297

Income

Total	Direct	Indirect	Multiplier
1556	457	1099	3.41

Employment

Total	Direct	Indirect	Multiplier
50	11	38	4.43

Table A5. Wisconsin

Output

	US		IL	IN	MI	OH	WI	RU
	m$	% [1]			% [2]			
1	28	3.1	0.11	0.03	0.02	0.03	1.41	1.51
2	16	2.3	0.06	0.02	0.04	0.04	1.04	1.07
3	43		0.01	0.00	0.00	0.00	0.02	0.03
4	66	1.9	0.08	0.02	0.01	0.02	1.42	0.34
5	76	1.7	0.13	0.05	0.04	0.04	1.20	0.28
6	87	9.6	0.64	1.63	0.36	0.60	4.26	2.15
7	85	2.7	0.28	0.10	0.20	0.21	1.45	0.43
8	395	1.4	0.09	0.02	0.04	0.03	1.08	0.14
9	102	1.5	0.03	0.01	0.01	0.02	1.32	0.15
10	188	2.6	0.16	0.15	0.60	0.29	1.09	0.30
11	175	2.2	0.14	0.04	0.08	0.06	1.43	0.44
12	207	0.3	0.03	0.02	0.02	0.02	1.10	0.13
13	671		0.09	0.02	0.03	0.02	0.10	0.59
Total	2140	2.7	0.19	0.08	0.12	0.09	1.33	0.88
			152	60	99	72	1059	698
Direct	794							
Indirect	1346							
Multiplier	2.70							
Net Exports			41	14	30	20	191	195

Income

Total	Direct	Indirect	Multiplier
576	160	415	3.59

Employment

Total	Direct	Indirect	Multiplier
20	5	15	4.06

Table A6. Rest of US

Output

	US		IL	IN	MI	OH	WI	RU
	m$	% [1]			% [2]			
1	4824	1.7	0.01	0.01	0.00	0.01	0.00	1.61
2	1346	2.2	0.02	0.01	0.01	0.02	0.00	2.17
3	1347		0.00	0.00	0.00	0.00	0.00	0.02
4	1618	3.6	0.10	0.05	0.04	0.05	0.17	3.16
5	4123	2.0	0.03	0.03	0.02	0.02	0.01	1.93
6	3069	9.3	0.28	0.66	0.27	0.53	0.18	7.40
7	2930	2.4	0.11	0.06	0.14	0.17	0.07	1.80
8	11461	1.3	0.05	0.02	0.03	0.03	0.04	1.15
9	8763	1.2	0.01	0.00	0.00	0.01	0.02	1.21
10	10551	1.6	0.02	0.04	0.18	0.10	0.02	1.24
11	5420	2.9	0.08	0.04	0.06	0.06	0.07	2.59
12	10980	1.3	0.01	0.01	0.01	0.01	0.01	1.21
13	17326		0.04	0.01	0.02	0.02	0.02	0.32
Total	83760	2.07	0.07	0.04	0.07	0.06	0.04	1.78
Direct	56284							
Indirect	60049							
Multiplier	2.07							
Net Exports			776	382	904	720	393	16577

Income

Total	Direct	Indirect	Multiplier
23329	10543	12786	2.21

Employment

Total	Direct	Indirect	Multiplier
744	295	449	2.52

Note. % [1] stands for the percentage change in national output relative to the initial shock amount in Illinois. For example, the sector 1 increases 4824 m$ nationally in accordance with 10% export increase in all merchandise sectors in the rest of US. This is the same for inter-regional, inter-sectoral multiplier: Row-sum of % [2] equals to % [1]. For sector 3 and 13, refer to the main text. 'Net Export' stands for the state-wise net export outside to the state. Thereby, it includes inter-state flows as well as international exports.

Endnotes.

[1] See Israilevich *et al*. (1997) for a more detailed discussion of the structure of the model system.

[2] The Gini-index is initially designed to measure industrial market power, and, in spatial economics, is based on the comparison between the geographic patterns of employment for one industry and in the aggregate.

[3] These percentage numbers (34.9, 34.2) can be obtained in Table A3 in Appendix. The Rest US number of 34.2 is the total inter-regional (RU form MI) output multiplier 0.93 divided by total net multiplier (2.7 = 3.7 - 1). The MW number comes from a similar calculation.